Stochastic Time Series Modeling for ISO-NE

Overview of Work

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Purpose

- Provide stakeholders an overview of the DNV GL stochastic time series analysis of variable energy resources (VER)
- Describe 2021 update to the VER time series data

Overview

- Background
  - 2020 ISO-NE VER Data Set
- Stochastic Time Series Analysis
  - Expansion of 2020 ISO-NE VER Data Set
  - Stochastic Engine (SE)
  - Key Performance Indicators (KPI) Analysis
- 2021 VER Data Series
  - Historical 2020 Data Update
  - New Facility Additions

Background

- During 2019 it became apparent to ISO-NE that a new consistent dataset of offshore wind was needed to serve as inputs to multiple studies across the organization
  - 2019 Economic Studies
  - Transmission Planning Study Assumptions
  - Energy Security Analysis

- We hired DNV GL at the end of 2019 to use their weather modeling software and develop a historical data set of all existing wind plants and future offshore wind plants from 2012-2018. This work was presented to PAC in February 2020 with two presentations
  - ISO-NE presentation and DNV GL presentation

- In early 2020, DNV GL updated the data set with an additional year of historical data and recalibrated the models to create an updated 8 year data set from 2012-2019. (e.g., if a modeled wind farm had two years of historical data instead of one, the model would be recalibrated to more closely match the longer historical record)

- In Summer of 2020, the ISO hired DNV to create a stochastic data set from an expanded historical modeled data set from which the results of that study are being presented today
  - July 22, 2020 ISO-NE PAC scope of work presentation
  - 2020 ISO-NE Variable Energy Resource (VER) Data Series (2000-2019) Rev.3

- In Fall of 2020, the ISO hired DNV to expand and recalibrate the historical data set to include 2020 historical data and additional hypothetical wind/solar plants
  - 2021 ISO-NE VER Data Series (2000-2020) to be posted in Mar-Apr 2021

2020 ISO-NE VER Data Set

- The 2020 ISO-NE VER data set contained hourly time series data for wind resources in New England for 8 years (2012-2019)
- This data set was created using NASA satellite information and advanced modeling software from DNV GL to create historical time series profiles based on New England weather conditions
- The data set was then calibrated with available recorded data to get the best fit possible
  - NOTE: The data set will not match historical values hour-by-hour, since it is based on a model, but the data should still follow overall weather trends and magnitudes and be statistically similar to recorded values
- The data set included the following information
  - 37 existing onshore and 1 existing offshore wind plant wind speed profiles
  - 12 future offshore wind plant wind speed profiles (4 state contracted and 8 hypothetical in BOEM lease area south of Cape Cod)
  - Aggregate wind power profiles (1 onshore and 1 offshore)
    - NOTE: Individual wind plant power profiles are considered market sensitive under the ISO Info Policy
- Revision 2 of this data set was posted to the PAC website on May 1, 2020 (Rev 0 and 1 included minor updates that are detailed in the read me file in the data set)

STOCHASTIC TIME SERIES ANALYSIS

Expansion of 2020 VER Data Set and Stochastic Engine

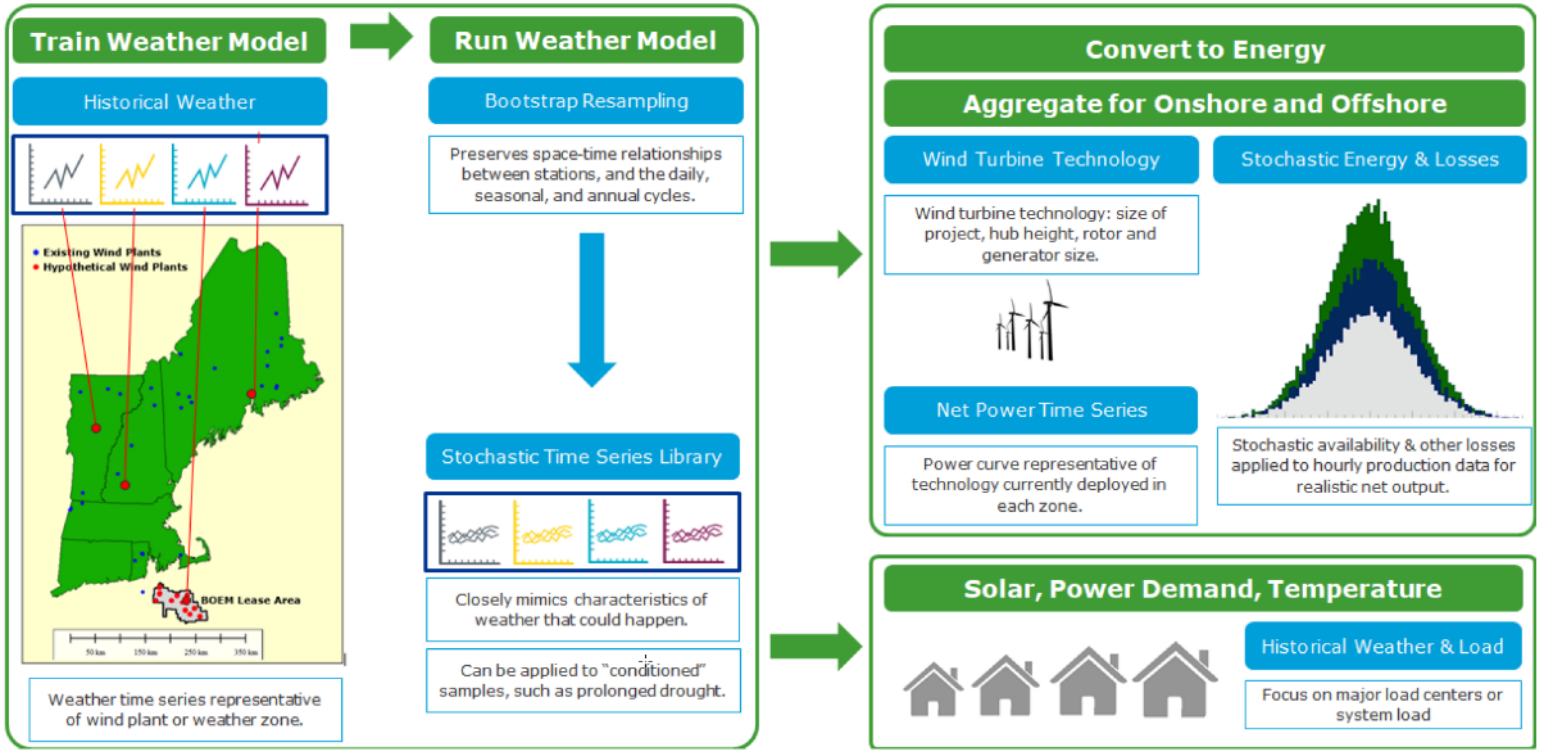
Expansion of 2020 ISO-NE VER Data Set

- In order to provide enough historical weather events for the Stochastic Engine, DNV GL recommend the historical VER data set should be expanded to 20 years
- The historical data set also needed to include solar and load profiles for the full 20 years to provide the co-dependencies between wind, solar, and load
- Revision 3 of the 2020 ISO-NE VER data set was posted on September 21, 2020 and contains hourly time series data for variable energy resources, load, and weather data in New England for a full 20 years (2000-2019)
- The expanded data set added the following information
  - All previous data from Revision 2 expanded to a full 20 years (2000-2019)
  - Aggregate behind-the-meter solar photovoltaic (PV) power profiles by Load Zone
  - Load (gross minus energy efficiency) and weather (temperature, relative humidity [RH], and global horizontal irradiance [GHI]) profiles by Load Zone

Stochastic Engine

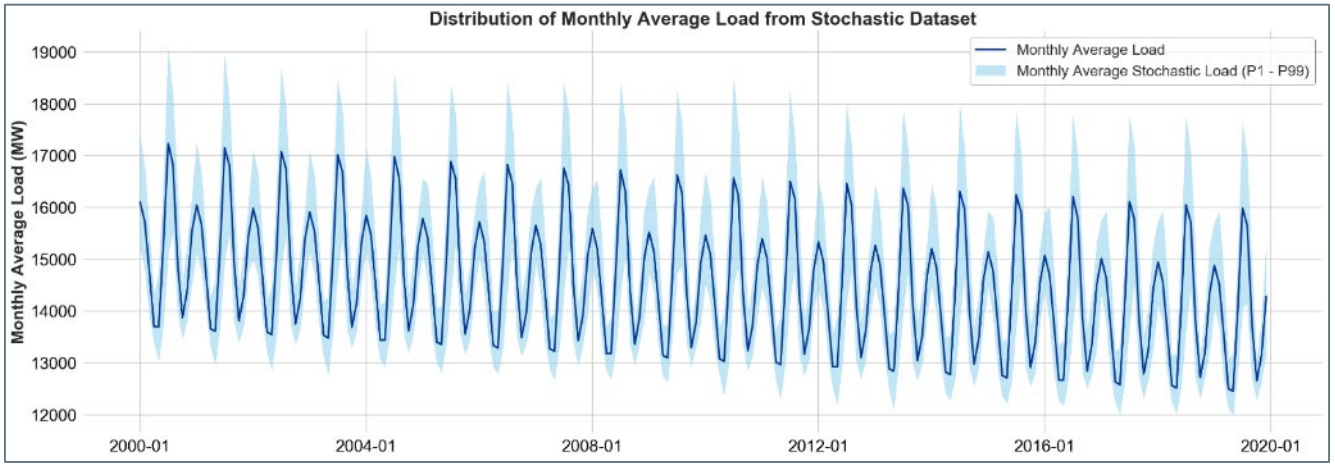
- The Stochastic Engine (SE) is a tool developed by DNV GL to statistically tackle time-series-based problems at scale. It can resample any time series (wind speed, irradiance, price, load) into parallel, plausible, scenarios while preserving all the relationships within the data and between the signals.
- The weather-to-generation models will then simulate the expected power production for each weather scenario, creating at least 20,000 years worth (1,000 20-year simulations) of hourly time series of weather and power outputs for each wind plant, zonal solar, and zonal load.
- Each time series will preserve the correlations from year-to-year, month-to-month, temperature-to-load, and zone-to-zone.
- Each 20-year simulation (also referred to as a realization) can be thought of as an alternate reality of weather conditions that have the same overall climate of New England.
- The stochastic data set is LARGE. It contains **175.2 million hours** worth of data and is **512 GB** in size.

Stochastic Engine, cont.



Stochastic Engine, cont.

- The SE preserves all trends present in the original data set. The figure below presents the distribution of monthly mean load values calculated from the 20,000-year stochastic data set. The original 20 years of input gross load data exhibited a downward trend, in part due to the implementation of energy efficiency programs in recent years. The stochastic data set preserves this trend. The monthly average loads of the data set are shown in the graph below.



STOCHASTIC ANALYSIS RESULTS

Key Performance Indicators

Key Performance Indicators (KPIs)

- The ISO prioritized the following KPIs for DNV GL to analyze in the stochastic data set
  1. Reliability of VER during cold snaps / heat waves
  2. Probability of wind and solar droughts/lulls
  3. Correlation of load, wind, and solar
  4. Representative 8760s
  5. Distributions of wind at peak(min) gross(net) load
  6. Intra-day variability of VER (ramping)
- The ISO had also proposed analyzing the following KPIs, but did not have enough budget in this round to complete
  - Storage requirements for VER to reduce resource variability
  - The probability of high-wind shutdown events for offshore wind
  - Analysis of impacts of upcoming 2024 solar eclipse
- A detailed presentation was made at the Planning Advisory Committee (PAC) on February 17, 2021 describing the results of this work
  - A final report will be posted on the PAC website

2021 VER DATA SERIES

Historical 2020 Data Update and New Facility Additions

2021 VER Data Series – Historical 2020 Update

- The ISO worked with DNV GL to update the 2020 historical data set (2000-2019) and add historical weather for 2020 to augment the model to 21 years (2000-2020)
- Additional historical output from load, wind, and solar will also be reviewed to update the bias and calibration of the models

2021 VER Data Series – New Facility Additions

- In addition to the annual update, the ISO had budget to add new hypothetical wind and solar facilities to explore resource diversity in areas where the region currently doesn't have any existing facilities
  - Note: The new hypothetical wind and solar facilities are NOT included in the stochastic data set described earlier
- In an effort to balance available budget and interest in modeling new hypothetical plants, the following facilities were added to the historical model
  - Six new hypothetical 1,200 MW offshore wind plants off the coast of MA, NH, & ME
    - Located in Federal waters up the coast from southeast of Cape Cod to the Canadian border
  - Four new hypothetical onshore wind plants in previous cluster study regions
    - Two 600 MW facilities, one in Western Maine and one in Central Maine
    - Two 1,200 MW facilities in Northern Maine
  - Seven new hypothetical 100 MW utility scale solar facilities
    - One in VT, NH, MA, CT, and RI and two in ME
    - Located in vicinity of existing or proposed utility scale facilities
- Note: These facilities' locations do not indicate an ISO preference or any indication on feasibility of interconnection. They are for hypothetical purposes only to examine the diversity of wind/solar resources in regions that currently do not have an existing facility

2021 VER Data Series – New Facility Additions, cont.

Offshore Wind Plant	Latitude	Longitude	Hub Height (m)	Wind Plant Capacity (MW)	State
Cape Cod	41.46250	-69.5742	150	1,200	MA
Boston	42.27708	-70.2728	150	1,200	MA
Seabrook	42.82307	-70.2638	150	1,200	NH
Wyman	43.72208	-69.0470	150	1,200	ME
Bar Harbor	44.22864	-67.8431	150	1,200	ME
Calais	44.50961	-66.9413	150	1,200	ME

Onshore Wind Plant	Latitude	Longitude	Hub Height (m)	Wind Plant Capacity (MW)	State
Maine South	44.60497	-70.8989	120	600	ME
Maine Central	45.07148	-70.0202	120	600	ME
Maine North 1	46.12256	-68.5006	120	1,200	ME
Maine North 2	46.91812	-68.1691	120	1,200	ME

Utility Solar Plant	Latitude	Longitude	Approx. Elevation (m)	Solar Plant Capacity (MW)	State
Spencer	42.28559	-72.0101	259	100	MA
Cranston	41.73384	-71.5282	85	100	RI
Hartford	41.88470	-72.5482	50	100	CT
Carroll	44.03158	-71.0348	125	100	NH
Addison	44.17892	-73.2494	59	100	VT
Hancock	44.43843	-68.5905	90	100	ME
York	43.38082	-70.9327	119	100	ME

Timeline

- The 2021 ISO-NE VER data set (2000-2020) with the new facilities is expected to be posted on the PAC website in the March-April 2021 timeframe
  - Similar to previous releases, the wind power data will be aggregated into a single onshore and single offshore profile to avoid any market sensitive data related to wind-to-power curves
- The ISO is seeking input if either the stochastic data set with representative 8760 profiles, or the 2021 historical data set with additional onshore/offshore wind facilities, should be used in the Future Grid Reliability Study as an alternative to current modeling practices

Questions